APPENDIX

Guidelines for Monitoring and Studies

- *Text will be made available in Braille, large print, or audio tape, as requested.*

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I. INTRODUCTION

These guidelines provide a framework for the type and extent of monitoring recommended to assess the potential effects that development of large or complex sites may have on aquatic resources. The purpose of monitoring for large or complex sites is to identify the condition of site resources and to provide a basis to assess their sensitivity to potential changes accompanying development, to determine effective mitigating measures, or to disclose resultant alterations.

For any monitoring program, overall objectives for monitoring and principal concerns to be addressed should be identified. For each discipline, the guidelines define objectives and purposes for the monitoring parameters suggested.

An attempt was made to be comprehensive; however, these guidelines cannot fit every situation. For specific land development proposals, the suggested monitoring goals should be evaluated and modified if necessary. Specific monitoring parameters should also be evaluated in light of site-specific conditions to assure the monitoring goals are achievable. These refinements will ordinarily be made during the Master Drainage Plan (MDP) scoping phase.[1]

In addition to establishing specific monitoring goals and choosing parameters, locations, and sampling frequencies to support those goals, the sampling data should be evaluated periodically to determine if the expected information is actually being provided and whether the objectives of the monitoring can still be met. If not, an adjustment in the parameters and frequencies should be made. Reevaluation of the objectives may also be advisable. Figure A-1 diagrams a conceptual approach to monitoring that emphasizes the need for setting objectives and periodic evaluation to assure that those objectives are met.

1The guidelines were prepared for large residential or mixed residential/commercial projects. They are not intended to apply to forest conversion projects unaccompanied by development, although the 1990 Surface Water Design Manual included such situations as requiring MDPs.

These guidelines are organized in six main sections: (1) Introduction and overview of the guidelines; (2) Guidance for the written analysis to be provided in Master Drainage Plans; (3) Baseline monitoring; (4) Post-development monitoring; (5) Attachments; and (6) References.

Post-development monitoring acknowledges four basic types of monitoring which occur during the development cycle, from construction to occupancy. The four monitoring types include construction monitoring, implementation monitoring, facility performance monitoring, and resource monitoring. Construction monitoring is largely overseen by the Department of Development and Environmental Services (DDES) and will not be discussed further in the guidelines. Implementation monitoring assesses whether activities or actions were carried out as planned. For instance, if the MDP specified that a certain amount of native vegetation would be retained, implementation monitoring would determine whether the vegetation was, in fact, retained. Facility performance monitoring assesses whether a stormwater management facility functions as designed and whether it achieves given performance specifications. Lastly, resource monitoring assesses whether the complement of land use prescriptions, site design, best management practices (BMPs), and other site-specific mitigation measures identified in the MDP have the expected resource protection outcome. It is suggested that representative resources rather than individual resources be monitored. This would allow joint exploration of impact issues by more than one applicant and more efficient study design. The table below summarizes the types of post-development monitoring addressed in these guidelines, and the timing of monitoring in relationship to the typical sequence of project development.

Summary of post-development monitoring for MDPs:

Type of Monitoring	Timing of Post-Development Monitoring		
	Utility Improvements	Housing Commercial Improvements	Occupancy[2]
Construction monitoring	X (DDES)	X (DDES)	—
Implementation monitoring	X	X	X
Facility performance monitoring	X engineering (1 year)	—	X engineering water quality
Resource monitoring	X geotechnical hydrology	—	X geotechnical hydrology fisheries water quality wetlands

[2] Occupancy is defined as commencing when 75 percent of the permitted units are built and occupied.

Each of the main guideline sections is organized by discipline—engineering (where applicable), geotechnical, hydrological, fisheries, and water quality. Requirements for standard and limited scope MDPs, as well as criteria for selecting which site resources should be monitored, are given for each discipline.

The King County Surface Water Management (SWM) Division intends these guidelines to be a constructive and useful tool to provide predictability, establish expectations, and begin dialogue in a collaborative process where the goals of resource protection and development can be creatively and efficiently balanced.

A. OVERVIEW

These guidelines are organized by discipline and focus on the basic monitoring objectives stated in Section III, Baseline Monitoring. However, the guidelines in Section II, Analyses of Monitoring and Studies, also anticipate that professional judgment and interpretation of qualitative information will be used in written analyses in addition to monitoring data. In Section IV, Post-Development Monitoring, some of the objectives are expanded into hypotheses for further testing. Thus, although organized by discipline, the active focus of these guidelines is toward defining monitoring objectives and identifying testable hypotheses.

In most cases, interdisciplinary data and information are required to allow for adequate assessment and analyses. It is sometimes not obvious, however, how the disciplines interact. For instance, in the case of wetlands assessment, some information is asked for in the hydrology discipline and some in the water quality discipline. The guidelines for assessment then assume that data from both disciplines will be used to assess the sensitivity of wetland systems and the potential impacts of site development on wetlands. In order to make these interconnections more obvious from the outset, a summary of data interconnections is given below. This summary is organized by discipline, and integrates baseline and post-development monitoring parameters. It also identifies the hypotheses developed for each discipline.

B. SUMMARY OF MONITORING BY DISCIPLINE

***Note*:** Baseline, resource, and facility monitoring categories are integrated here.

1. Geotechnical

Mapping Recommended: Topography, soils, cross sections and stratigraphy, geology, and sensitive areas

Hypothesis: Disruption of normal stream channel processes is not occurring in the post-development period. Groundwater recharge quality and quantity are maintained following development.

Baseline Monitoring Recommended:

- Geologic exploration
- Hydrologic characterization
- Infiltration characteristics
- Groundwater levels
- Stream transects

Post-Development Representative Resource Monitoring:

- Groundwater levels
- Stream stability transects
- Groundwater monitoring wells. (See item 4., Water Quality.)

2. Hydrological Monitoring

Determine the following for lakes, wetlands, and closed depressions: bathymetry (approximate), outlet control, stage-discharge relationship, ordinary high water level, surface area, maximum dead and live storage volumes, and 100-year floodplain.

Determine the following for streams: surface water flow routing on-site, design storm flow rates, conveyance capacity of channel and control structures, backwater analysis, 100-year floodplain, Federal Emergency Management Agency (FEMA) requirements (if applicable).

Hypotheses, wetlands:

- Change in mean annual water level fluctuation does not exceed acceptable limits after site is fully developed.
- Summer drying does not extend more than two weeks beyond average pre-developed dry period.

Hypotheses, streams:

- Flow regime alterations are not causing erosion problems, habitat degradation, or more severe flooding.
- Low flows are not reduced beyond limits disclosed in the Environmental Impact Statement (EIS).

Baseline Monitoring Recommended:

Wetlands

- Staff and crest stage gaging, Class 1 wetlands (if using HSPF with regional parameters)
- Duration of summer drying (selected Class 3 wetlands)

Wetlands (continued)

- Instantaneous water level (7 months) for Class 1 wetlands (if using calibrated HSPF)[3]

[3] Seven months of winter (October - April) flow monitoring will be required for HSPF calibration, except when an annual water budget is needed to appropriately calibrate the model, in which case 12 months of continuous monitoring

Streams
- Level I, II, and III off-site analysis
- Crest gage with 7 months of continuous flow record (if using calibrated HSPF)
- Crest gage with monthly stage (if using other models)
- Rating curve for stage discharge relationship
- Meteorological records
- Groundwater levels across representative stream transect (upland to riparian)

<u>Post-Development Representative Resource Monitoring</u>:

Wetlands
- Staff and crest gage readings
- Duration of summer drying

Streams
- Stage/crest gage (above and below R/D pond outlet)
- Precipitation
- Duration and extent of summer drying groundwater levels

3. Fisheries

Hypotheses:
- Flow regime alterations are not causing a significant degradation of spawning and rearing habitat.
- Fish migration is not impeded by post-development changes in stream channels.
- Benthic community composition has not changed so markedly as to affect fish populations.

<u>Baseline Monitoring</u>:

Baseline assessment, including fish use, habitat, water quality, and riparian condition, based on King County Stream Survey Report Criteria (BALD, 1991). (See Section V., Attachment 4.)

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will be required. Resource concerns that warrant an annual water balance include the following:

- Groundwater recharge
- Summer (low flow) fish habitat conditions
- Class I wetland summer water levels

For those sites where the above hydrologic conditions are important, reliable impact assessment requires a full year of hydrologic monitoring for model calibration and water balance computation.

Post-Development Representative Resource Monitoring:

Site-specific information must be used to develop testable hypotheses.

4. Water Quality

Hypotheses, lakes:

- The trophic status of lake after development does not differ significantly from pre-development status.
- The concentration of zinc and copper in lake sediments in the post-development phase is equal to the concentration in the pre-development phase (level of significance = 0.75).

Hypotheses, fen/bog wetlands:

- The alkalinity of the bog post-development does not differ from the pre-development alkalinity (level of significance = 0.75).
- The range of monthly wet weather water levels does not change significantly after development (level of significance = 0.75).
- The vegetation community composition of the bog mat does not differ markedly from the pre-development community (may not be statistically testable from limited data set).

Hypotheses, streams:

- Summer temperature and DO conditions are not limited to aquatic life.
- The post-development wet weather phosphorus loading to downstream lakes is not greater than that predicted in the MDP (level of significance = 0.75).
- The benthic stream community composition has not shifted markedly after development.

Hypothesis, groundwater:

- Pollutants in groundwater near sensitive receiving sources are not significantly different in pollutant/nutrient content than in the pre-developed condition.

Baseline Monitoring:

Lakes

Nutrients (TP, TN)
Secchi depth
Temperature profile

Lakes (continued)

DO profile
Sediment metals (Zn and Cu)*
Air photo for macrophytes*

Fen/bog wetlands

Nutrients (TP, TN, ammonia, NO_2 + NO_3)
Ph
Major cations (alkalinity), anions
Staff and crest gage

Fungal and bacterial assessment*
Vegetation transect*

Streams
Nutrients (TP) (if downstream lake trophic status needs to be monitored)*
DO
Temperature
pH
Conductivity
Biotic community assessment
Flows (if into or exiting a Class 1 wetland monitored for water level fluctuations)*

Groundwater (for selected land uses only)
Nutrients (TP, SRP, NO_2 + NO_3)
pH
Fecal coliforms*
Pesticides*
Selected organic pollutants*
Piezometers with crest indication

Post-Development Representative Resource Monitoring:

Lakes
Nutrients (TP, TN)
Chlorophyll a
Secchi depth
Temperature profile
DO profile
Sediment Zn and Cu
Air photo for macrophytes

**** These parameters may be postponed until after the UPD or combined/UPD plat hearing on the plat.***

Fen/bog wetlands
Nutrients (TP, TN, ammonia, NO_2 + NO_3)
pH
Major cations (alkalinity), anions
Staff and crest gage
Fungal and bacterial assessment
Vegetation transect

Streams
Nutrients (TP)
DO
Temperature

pH
Conductivity
Biotic community assessment
Flows (if into or exiting a Class 1 wetland monitored for water level fluctuations)

Groundwater (for selected land uses only)
Nutrients (TP, SRP, $NO_2 + NO_3$)
pH
Fecal coliforms
Pesticides
Selected organic pollutants
Piezometers with crest indication

5. Engineering

Post-Development Facility Monitoring Only:

- Infiltration Facilities
  Hypothesis:
  Infiltration rates are within acceptable parameters.
  Monitor:
  Infiltration rate within facility

- Hydrology
  Hypothesis:
  R/D facilities store and release stormwater within the levels and flows expected within a 20% margin of error.
  Monitor:
  Staff and crest gage in R/D facilities

- Water Quality (wetponds)
  Hypothesis:
  Observed pollutant removal of water quality facilities equals target pollutant removal within a 35% margin of error.
  Monitor:
  TSS
  Turbidity
  Zinc, hardness
  pH
  Nutrients (TP, SRP)
  Depth of sediment in forebay (wetponds)

II. ANALYSES OF MONITORING AND STUDIES

The Master Drainage Plan (MDP) uses the information collected in the baseline monitoring phase to evaluate project impacts to resources and to propose adequate mitigation measures. Impacts and any proposed mitigation should be disclosed through the State Environmental Policy Act (SEPA) process, which ordinarily parallels the MDP process. The kinds of analyses and issues that the MDP should consider are identified below by discipline.

A. ENGINEERING ANALYSES

The following products and analyses should be included in the MDP:

1. Level I off-site analysis in accordance with the Surface Water Design Manual (SWDM)

2. Site plan

3. Environmental checklist

4. Volume capacity of wetlands, lakes, and closed depressions

5. Outlet controls of wetlands, lakes, and closed depressions

6. Level II and possible Level III off-site analysis in accordance with the SWDM

B. GEOTECHNICAL ANALYSES

The following areas should be analyzed in the MDP:

1. Suitability of stormwater storage and infiltration areas in relation to areas of geotechnical concern, such as steep slopes, slippage-prone geologic strata, and erosion-prone deposits

2. Assessment of erosion potential of slopes and stream channels

3. Assessment of relative phosphorus yield of site soils, for watersheds with phosphorus sensitive lakes or fen/bog systems, particularly in areas of potential erosion, such as along stream channels or areas of overland stormwater flow

4. Assessment of site sediment yield during construction and after development

5. Identification of direction of groundwater movement, discharge/recharge areas; effect of

development on groundwater recharge quality and quantity

6. Assessment of connection between surface water resources and groundwater, including interflow (i.e., groundwater supply to wetlands and streams)

7. Suitability of soils for infiltration systems, both large ponds and individual roofs

C. HYDROLOGICAL ANALYSES

The following analyses should be included in the MDP:

1. Hydrologic modeling of existing and developed conditions

2. An estimate of existing and developed condition flow rates and volumes

3. Determination of the appropriate drainage facility performance standards

4. Floodplain analysis

5. For Class 1 wetlands (including sphagnum fens and bogs):

   a. Location and approximate size, Cowardin (or SAO) classification, primary function and values assessment of wetlands. Determine the existing water level fluctuation from staff and crest stage data.

   b. Analyze changes in hydrology using the groundwater level study and a mass balance approach. Determine the impact of development changes on the wetland vegetation community and the existing functions and values. Identify mitigation measures to reduce significant impacts.

6. For Class 2 and 3 wetlands:

   - Estimation of the extent of alteration of groundwater and interflow to the site and adjacent wetlands

   - Determination of the effect of changes in hydrology on wetland vegetation

   - Qualitative estimation of the duration of the summer dry period after development

   - Examination of impacts of structures and outlet controls on wetland vegetation communities and functions and values, in coordination with the engineering studies

7. For unmonitored small streams, springs, and seepages:

    - Identification of streams and seepages on-site; connection between stream flow, interflow, and groundwater. If possible, estimate the prominence of these systems in overall site hydrologic processes.

    - Determination of the impact of site development on streams, springs, and seepages; connection to hydration of wetlands and stream flows

D. FISHERIES ANALYSES

The preliminary fisheries assessment should take into account the potential impact of the project and the relative size of the project's drainage contribution to the resource. The following should be included in the preliminary fisheries assessment discussion:

1. A map showing the location of all streams on-site, with the name and number of the stream identified on the map

2. A vicinity map showing drainages to major systems

3. Summary of information from public resource documents and any site-specific studies that have been done to provide initial site information regarding stream condition, fish usage, and classification and regulations. Such sources would include, but not be limited to:

    - Sensitive Areas Map Folio (King County, 1990)
    - King County Sensitive Areas Ordinance (SAO; King County, 1990)
    - Data from affected Tribes
    - Catalog of Washington Streams and Salmon Utilization (Williams, 1975)
    - Data from the King County Surface Water Management (SWM) Division Basin Planning Program, including Basin Plans and Reconnaissance Reports
    - Any site-specific studies previously done

4. A table or brief text form giving the following information:

    - Identification of all streams based on the common names and number system listed in the Catalog of Washington Streams and Salmon Utilization. Those streams not listed should be referenced by an identification system explained in the report.

    - Identification of streams according to the King County SAO definition. Streams are to be classified according to the rating system used in the Sensitive Areas Map Folio, and based on criteria established by the SAO (Class 1, two types of Class 2, and Class 3).

- Using historical documents, substantiate fish usage, flow regime, and known physical migration barriers.

A Level I, II, or III stream survey as outlined in the King County Stream Survey Report Criteria may be required on Class 1 and 2A streams or on systems with uncertain classifications. This would be based on information given in the preliminary fisheries assessment. Alteration of 15 percent or less of a contributing subbasin area to a resource would not require a Level III stream survey, except in cases where stream alteration is proposed. Information from the preliminary fisheries assessment should be provided to determine the final scoping of fisheries for the MDP. From the information provided in the preliminary fisheries assessment, the Level I, II, or III stream survey may be modified. Based on analyses from other disciplines and assessments performed on fisheries resources, a qualitative assessment of the sensitivity of fish populations to the alteration of the substrate and/or flow regime on rearing, spawning habitat, and migration should be provided. The applicant may need to refer to the King County Stream Survey Report Criteria, Level III survey to prepare a post-development monitoring plan.

E. WATER QUALITY ANALYSES

Water quality is assessed in MDPs so that the sensitivity of site and downstream resources to changes in chemistry and biology related to the development can be identified, and potentially significant impacts can be determined and mitigated. For large or significant resources, direct samples of water and biota, or recent data collected by others, are needed to make this assessment. For smaller resources, knowledge of the ecological functions and values of the resource and literature studies are sufficient to determine likely impacts without direct monitoring data.

1. Analyses for Monitored Site Resources

In addition to presenting the water quality and biological data, along with appropriate validation documentation, the MDP should present analysis of the data sufficient to judge the likely impacts of the proposed development on the resources monitored. Appropriate mitigation measures should also be identified.

Typically, this will include discussion of the following topics, where applicable:

a. <u>Lakes</u>

Existing condition of the resource: Discussion should include information such as the general ecological information, trophic status including TP/TN ratio, water residence times, algae or macrophyte problems, sensitive fish use (from reports), summary of field data, and discussion of lake water in relation to water quality standards.

Impact analysis: The following should be presented:

- Determination of the impacts of construction-generated pollutants to the lake, including the overall phosphorus loading to the lake and effect on the internal sediment loading of the lake. Soil maps and characteristics determined in geotechnical investigations should be used.

- Determination of the likely concentration of pollutants in stormwater runoff from the site after development, based on data in the literature and collected by local agencies

- Determination of the reduction in pollution concentration, based on the proposed best management practices (BMPs) and field studies of BMP effectiveness

- Analysis of the impact the resulting pollutant concentration would have on the lake, with special attention to areas of principal concern determined during baseline assessment and monitoring. (See Section III, Baseline Monitoring.) Analysis should be based on several representative field studies. Use of the Nationwide Urban Runoff Program (NURP) model (U.S. EPA, 1983) to estimate removals is not recommended because of over-estimation problems with the model. The NURP model may, however, be used to compare removals of two treatment techniques, or other studies which minimize the over-estimation bias of the model.

- Analysis of the impact the additional loading would have on the lake

- Identification of mitigation measures to reduce significant impacts

Note: For areas of uncertainty, estimate a high, average, and low case, or give an estimate of the most likely case with the amount of uncertainty in the estimate stated.

b. Sphagnum fen/bog wetlands

The following information should be assessed and presented:

- Determination of the existing water chemistry, emphasizing buffer and alkalinity regime and nutrient concentrations, both for nitrogen and phosphorus. Contrast with other aquatic systems (lakes or more typical wetlands).

- Determination of the change in the volume of water entering the wetland after development, including route of entry (surface, interflow, and groundwater)

- Estimation of the effect change in groundwater and interflow would have on fen/bog chemistry

- Determination of the effect of impacts of construction-generated pollutants on the fen/bog, including the overall phosphorus loading

- Determination of the likely concentration of pollutants of concern (alkalinity, pH, nutrients) in stormwater runoff from the site after development, based on data in the literature and collected by local agencies

- Determination of the reduction in pollution concentration, based on the proposed BMPs and field studies on their effectiveness

- Analysis of the impact the resulting pollutant concentration, including phosphorus and nitrogen, would have on the fen/bog, with special attention to the areas of principal concern in the Baseline Monitoring Section of the guidelines. Discuss the effect of additional nutrient (both P and N) loading on the fen/bog. Use sensitivity analysis to bracket the range of impacts that might be experienced.

- Identification of mitigation measures to reduce significant impacts

c. <u>Streams</u>

Determination of the following should be included in the MDP:

- Existing stream geomorphological processes, based on field studies. (See Geotechnical category in the guidelines.)

- Existing water chemistry characteristics for storm events, relationship with state water quality criteria

- Biotic function and status of streams, including invertebrate and vertebrate communities

- Sensitivity of invertebrate communities to substrate types and flow regimes, based on literature such as Merritt and Cummins, 1973 and 1989[4], and J.V. Ward, 1993[5]

- The effect of impacts of construction-generated pollutants on the stream, including physical habitat alteration (sedimentation, embedding of cobble, particle size distribution). (Coordination with the geotechnical studies is needed for this analysis.)

- The likely concentration of pollutants in stormwater runoff from the site after development, based on data in the literature and collected by local agencies

- The reduction in pollution concentration, based on the proposed BMPs and field studies of BMP effectiveness

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[4]Merritt R.W. and K.W. Cummins, <u>An Introduction to the Aquatic Insects of North America</u>, Kendall/Hunt Publishing Company, Dubuque, Iowa, 1978.

[5]Ward, J.V., <u>Aquatic Insect Ecology</u>, John Wiley & Sons, Inc., 1993.

- Analysis of the impact the resulting pollutant concentration would have on the stream, with special attention to the areas of principal concerns given in the baseline monitoring section of the guidelines. Analysis should be based on several representative field studies.

  Use of the NURP model to estimate removals is not recommended because of overestimation problems with the model. The NURP model may, however, be used to compare removals of two treatment techniques, or other studies which minimize the overestimation bias of the model.

- Identification of mitigation measures to reduce significant impacts

Note: For areas of uncertainty, estimate a high average and low estimate, or give an estimate of the most likely case with the amount of uncertainty in the estimate stated.

d. <u>Groundwater</u>

- Determination of existing phosphorus concentration in groundwater, relationship of concentrations to other phosphorus sources, and relationship of the phosphorus budget to sensitive lakes of fen/bog wetlands

- For bog/fen wetlands, also examine any increase in nitrogen (NH_3, NO_2, and NO_3) in groundwater.

- Interconnections between groundwater flow and surface water resources on-site

2. Analysis for Site Resources that were not Monitored

a. <u>Water quality facilities</u>

When proposing a design that is functionally equivalent to the Surface Water Design Manual (SWDM), the following information should be provided for water quality facilities:

- Theoretical basis for design
- Criteria for facility sizing
- Pre-treatment requirements
- Siting limitations to be observed
- Maintenance requirements
- Literature or local studies indicating the performance of the facility for target pollutants

In addition, a variance argument should be presented, indicating clearly why the facilities recommended will achieve a functionally equivalent level of performance (based on published literature or local or regional studies), and will be equivalent with respect to health and safety concerns, maintenance requirements, and aesthetic aspects. Specific guidelines are given below:

Guidelines for determining equivalent performance: Determine the pollutant removal effectiveness for the pollutants of concern for each facility type. The combined pollutant removal effectiveness of a proposed treatment train can be determined using the following formula:

$$\text{Combined removal} = 1 - (P_a)(P_b)$$

where P_a = percent of pollutant remaining after treatment in facility a and P_b = percent of pollutant remaining after treatment in facility b.

Compare the results to the train prescribed by the SWDM to determine if the combined removals are equivalent or nearly so.

Health and safety concerns: Of primary concern is the potential for accidental drowning. Fencing, safety benches, and emergency escape features should be considered for any BMP designed to hold standing water. Objectionable odors and the potential for mosquito breeding are also considerations that should be examined.

Maintenance information should include the type of maintenance needed to assure that expected performance is achieved. Specify the types of activity needed, their recommended frequency, and equipment and access requirements. For planted BMPs, include plant cultural needs, including minimum soil fertility, harvesting, plant mixes by genus/species, plant spacing or seeding specifications, and reseeding recommendations. Limits of soil water logging, under-drain requirements, and leveling considerations should be addressed.

Aesthetic considerations should include general integration with the landscape, vitality, and visual interest of the vegetation; opportunities for multiple uses; minimizing entrapment and visibility of wind-carried litter; management of floatables, scum, and algae; and management of summer drought periods.

III. BASELINE MONITORING AND STUDIES

A. GEOTECHNICAL STUDY

1. Standard MDP

a. Geology/subsurface hydrology

- Purpose for study:
  - To determine the interconnection between groundwater and surface water resources.
  - To determine suitability and potential hazards of the site for placement of surface water facilities.
  - To determine the flow direction of groundwater.

- Principal concerns:
  - Identifying opportunities for infiltration of stormwater
  - Slope stability in connection with retention/detention (R/D) pond placement
  - Potential transport of pollutants to surface water resources or drinking water sources

- Mapping requirements (to be performed once):
  - *Topographic map*: Used to determine areas of sensitivity for further investigation Detail desired: Contour Intervals (5 feet general, 2 feet steep slopes), Scale (1" = 200_)

  - *Site cross sections and stratigraphy:* Used to assess surface and groundwater interaction and slope stability; determine areas of sensitivity for further investigation. Information will be used to model assumptions under pollutant transport assessment and stormwater facility siting and design. Detail desired: 1" = 200_ horizontal axis; 1" = 20-50_ vertical axis. Frequency of data: A minimum of two alignments are needed, one north/south, one east/west (three are preferred at larger sites).

  - *Soils map:* Detail desired: 1" = 200_. Based on USDA soil survey for King County (1973). Department of Development and Environmental Services (DDES) requirements to be followed for maps.

  - *Surficial geology map:* Detail desired: 1" = 200_. If production wells are drilled, well logs should also be submitted.

  - *Sensitive Areas Ordinance (SAO) Areas restrictions map:* Include seismic hazard, erosion hazard, steep slopes, mining hazard. Detail desired: 1" = 200_

- Parameters to monitor:
  - Groundwater level: Piezometers should be used to determine the seasonal groundwater depth and gradient on-site and suitability of the R/D and infiltration facility sites in high water table areas.

Frequency of monitoring: Number of piezometers depends on site characteristics and complexity, but in general, two sets of piezometers should be installed in each subcatchment, one set at the headwaters and one at the outlet. The number and depth of piezometers should be based on the stratigraphy, with the goal of measuring both shallow perched and deeper water tables. Monthly readings should be made, but may be reduced to wet season/dry season readings for less complex sites.

Duration of monitoring: One year

- Geologic study:
  - *Subsurface investigation* should be done in representative areas of the site, with more detail provided around sensitive areas or areas where development impacts are likely. Soil types should be determined, and tests including grain size should be run on representative samples. At least one CEC test should be run on a selected soil sample in each area where a large-scale infiltration facility is proposed. Existing steep slopes or other sensitive areas should be addressed, particularly with respect to impacts that may result from changes in drainage resulting from development.

  - *Infiltration sites:* The geotechnical engineer shall determine which areas of the site may be suitable for infiltration facilities, either large-scale (ponds) or small-scale (such as roof downspout systems). At least two test holes should be dug at each possible large-scale facility site. Soil logs and a discussion of the geologic origin and estimated hydrologic properties of the soil units should be provided. Test pits or borings should extend at least 5 feet below the probable bottom elevation of the facility, and at least one test hole should reach the water table. If the water table is very deep, the test hole need not extend more than one-fourth the maximum width of a pond below the expected bottom elevation of the pond, or more than 5 feet below the bottom of a tank. If there is any question about the actual wet season water table elevation, measurements shall be made during the period when the water table level is expected to be at a maximum.

  - *Infiltration rate tests* may be required in order to demonstrate the feasibility of infiltration facilities or to provide an estimate of the potential outflow rates for existing areas providing infiltration, such as closed depressions or wetlands. Infiltration rates should be determined using the method described in the latest version of the SWDM.

b. Streams

- Purposes for monitoring:
  - To assess stream channel stability and sensitivity to erosional processes.
  - To establish a baseline from which future effects can be measured.

- Principal concerns:
  - Aggravation of downcutting
  - Channel and bank stability under altered flow regimes

- Monitoring:
  - *Stream study reaches with transects*: Transects should be done for Class 1 streams and selected Class 2 and 3 streams. Criteria for whether Class 2 and 3 streams should be studied include factors such as high gradient, high erodibility, channel stability, substrate, and project contributing area.

Frequency of monitoring: For each stream studied, a minimum of one study reach approximately 300 feet in length should be established with three cross-sections per reach provided. Cross section elevation surveys shall be used to develop a channel profile. Streams with degradation or aggradation characteristics may require additional reaches to be monitored. (Also see B., Hydrology, below).

2. Limited Scope Master Drainage Plan (MDP)

1. Stream monitoring can be foregone if a subbasin comprises less than 15 percent of the upstream catchment of any watercourse or lake, or if the percent forest in the site subbasin will exceed 85 percent in the post-development phase.

2. All other standard scope baseline monitoring requirements would apply.

B. HYDROLOGY

1. Model Selection for Hydrologic Monitoring

a. Modeling

In selecting a hydrological model for an MDP, several factors should be considered, including:

- Site area relative to drainage area
- Proposed land use changes
- Land cover and proposed alterations
- Topography
- Soil type

- Stratigraphy
- Drainage system characteristics
- Surface and groundwater interaction
- Sensitivity and importance of downstream resources
- Downstream problems

Site development typically results in changes in flow rates as well as overall water volumes. Event models, such as the Santa Barbara Urban Hydrograph (SBUH), predict changes in flow peaks and duration of peaks. Modifications to event models, such as the 7-day modification to the SBUH, adjust for particular aspects of concern. However, event models cannot predict changes in water volumes. A continuous model is needed to explore questions related to water volume. In addition, some continuous models such as the HSPF model contain a groundwater element. There are several situations encountered in drainage planning for which water volumes or surface/groundwater interactions are important. These include the following:

- Volume flooding situations
- Low flow or dewatering effects on streams
- Groundwater recharge issues
- Erosion or habitat changes in sensitive streams
- Wetland or lake water level fluctuations

If these situations are of concern in the planning area, or if the planning area is large in relation to the drainage catchment (35% or greater), a continuous model should be used. Table A-1 lists four hydrologic model options:

- Calibrated HSPF, a continuous model
- HSPF using regional rather than site-specific parameters
- King County Runoff Time Series (KCRTS), a simplified continuous model lacking a groundwater component
- SBUH, the Santa Barbara Urban Hydrograph event model

Criteria for application of the models to specific sites, an indication of the sufficiency of the model to examine the situations identified, and general monitoring requirements are also indicated.

Table A-1. Hydrologic Model Options

Model	Application Criteria	Resource Issue Suitability						Monitoring Needs
		Volume flooding	***Stream low flows, dewatering***	***Ground-water recharge***	***Stream erosion habitat***	***Wetland WLF***	***Site > 35% of catchment***	
Calibrated HSPF (site-specific land parameters)	Site hydrology and soils complex hydrologically	For high-risk, frequent problems	Usually needed for high-value resource streams	Typically needed	For high-value resource streams	Usually needed for Class 1 wetlands	Not usually needed	Continuous stream flow groundwater levels rainfall infiltration rates continuous wetland stage
HSPF regional land parameters, with anecdotal information and records	Site soils react predictably in pre- and post-development.	Usually OK for lower risk problems	OK, especially for till soils	Maybe OK	Maybe OK	Maybe OK	OK	Anecdotal observations, existing data, well logs; monthly stream flows, wetland stage and groundwater levels for site assessment
KCRTS	Best for small subbasins, and if no groundwater component needed	Maybe OK	No	No	No	Maybe OK for winter storm elevations	OK	Monthly stream flows, wetland stage and groundwater levels for site assessment
SBUH* (24 hour or 7 day)	HSPF recently run; mitigation standards based on SBUH	No	No	No	No	No	No	Monthly stream flows, wetland stage and groundwater levels for site assessment
No model	Soils fully infiltrative No detention releases proposed	No	No	No	No	No	No	No monitoring

* Will be replaced by KCRTS

b. Wetlands

For wetland catchments in which the proposed project comprises a small proportion of the catchment area, or for which forest retention is extensive, no water level monitoring need be done. The following graph gives guidelines for combinations of catchment size, project forest retention, and project impervious area that would allow waiving of the monitoring and modeling requirements for Class 1 wetlands. Please note that the graph does not apply to fen/bog wetlands, which are more sensitive to fluctuation.

If more than two Class 1 wetlands exist on a site, two wetlands that represent a lower and a higher fluctuation status should be selected for monitoring. Vegetation and physical attributes, such as outlet constriction, should be used to approximate the level of fluctuation for selecting representative wetlands.

If a Class 1 wetland has more than three areas with distinct surface elevations, an attempt will be made to reduce the number of gages by looking for areas with similar fluctuation characteristics, based on outlet configuration and wetland morphometry.

To use this graph, first determine the percentage of the project area to be covered with impervious area, and then determine which line applies to the project. Next determine the ratio of project area to the total wetland basin area. This is the x-axis coordinate. Then determine the percent of the project area that will remain dedicated in forest cover. This is the y-axis coordinate. If the intersection of the coordinates lies below the impervious area line, water level monitoring may be required. If it lies above the line, water level monitoring is not required.

2. Standard MDP

- General purposes for hydrological monitoring:
  - To calibrate HSPF model of Class 1 wetlands and other volume-related resource problems.
  - To determine the pre-development water balance (how rainfall is partitioned between surface flow, interflow, groundwater, and evaporation).
  - To determine requirements for facility design and performance.
  - To allow comparison of pre- and post-developed conditions.

a. Lakes, wetlands, and closed depressions

- Purposes for lake, wetland, and closed depression monitoring:
  - To assess the function of lakes, wetlands, and depressions in storing and releasing stormwater.
  - To determine the on- and off-site flood potential of site development.

- Principal concerns:
  - Loss of live storage and infiltration function of lakes and wetlands
  - Aggravation of flooding
  - Stability of outlet control conditions
  - Effect of increases in outlet flow rates and volume on downstream channels

- Parameters to determine:
  - Bathymetry based on site topography and transects
  - Outlet control description and measurement
  - Stage-discharge volume relationship of outlet control
  - Surface area of open water, ordinary high water levels
  - Dead storage maximum elevation and volume
  - Live storage maximum elevation and volume
  - 100-year floodplain

b. Wetland hydrology

- Purpose for wetland monitoring:
  - To determine baseline water level fluctuation in relation to vegetation communities and amphibian habitat.
  - To establish a baseline condition from which to measure potential post-development changes.

- Principal concerns:
  - Changes in spring water level fluctuation of wetlands and lakes and resultant habitat changes
  - Changes in groundwater and interflow in relation to wetlands and streams

- Parameters to monitor:
  - *Water level for Class 1 wetlands:* Frequency per station:

Instantaneous staff water level	Monthly for 7 months (6 during wet weather (October - May))*
Crest stage gages	Monthly for 7 months (as above)*

  - *Number of stations:* One station per wetland. Location of gage should be in the permanent pool area of the wetland.

  - Inflow and outflow rates. (See Stream Monitoring.)

The duration of summer drying should be recorded for Class 1 wetlands, provided they dry during the summer and selected Class 3 wetlands. This criteria does not refer to the extent of dry area exposed, but simply to the length of time the pool drys down to the soil surface almost everywhere in the wetland. If more than two Class 1 wetlands occur on a site, two representative systems likely to experience development within their catchments should be selected for monitoring. In general, Class 2 and 3 wetlands need not be gaged, but impacts to their hydrology should be addressed qualitatively.

(Also see Groundwater Monitoring, Water Quality Section.)

c. <u>Streams</u>

- Purposes for stream monitoring:
  - To determine the sensitivity of streams to changes in flow rates and volumes.
  - To determine on-site and downstream flooding potential.
  - To allow calibration of HSPF model; or rough verification of single-event hydrologic models.
  - To determine the conveyance capacity of streams.

- Principal concerns:
  - Erosion potential of increased flows (rates and volumes); aggravation of flooding conditions
  - Adequate conveyance and channel protection
  - Fisheries habitat degradation due to altered flow regime

**** When summer low flows or drying are of concern, 12 minutes of continuous monitoring will be required.***

  - Potential reduction in low flows to streams and resultant effects of flow alterations on biota. (See Water Quality.)

- Provide input on the effect of erosion and downcutting on nutrient balance of downstream lakes, oligotrophic or ombrotrophic wetlands (see Water Quality).

- Parameters to determine:
  - Surface water flow routing based on site topography and field inspection
  - Design storm flow rates
  - Conveyance capacity of channel and structural controls
  - Backwater analysis (where appropriate)
  - 100-year floodplain of stream
  - Federal Emergency Management Act (FEMA) requirement parameters (if applicable)

- Parameters to monitor:
  - Level I, II, and III off-site analysis
  - Crest gage with continuous record of stage for calibration of HSPF, if required (stage to be converted to flow following stream flow gaging procedures)
  - Crest gage and monthly stage/flow measurement (for rough verification of hydrologic models and hydraulic models such as rating curves for outlet controls)
  - Develop rating curve for stage-discharge relationship at the gaging station. HSPF modeling will require development of f-tables for stage discharge and volume relationships.
  - Meteorological records are needed where calibrated HSPF modeling is applied. Site precipitation recording station, evapotranspiration records, and long-term precipitation record requirements are given in Attachments 1 and 2.
  - Duration and extent of summer groundwater levels across representative stream cross sections (upland to riparian)

- Monitoring stations required:
  - Number of flow gaging stations is determined based on modeling method and subbasin characteristics. If stream flow is needed to determine wet weather phosphorus loading to downstream lakes, 7 months of monitoring data should be collected between October and May (see Water Quality). Continuous monitoring is preferred, but estimation from a rating curve and staff gage is acceptable if continuous data are not needed for hydrological modeling.

  - *When site-specific HSPF modeling parameters are required:* Sufficient gaging of inflow and outflow streams is needed to characterize the existing hydrology of the resource to be studied.

Hydrologic monitoring requirements are primarily based on the hydrologic modeling method selected for the site. Decisions on flow gaging instrumentation and record are dependent likewise on the scope of modeling and the model's input data requirements.

Table A-1 in Section III, B., provided criteria for the types of models that can potentially be applied to the most frequently encountered volume-related resource problems. Several monitoring requirements are also given. Specific modeling and hydrologic monitoring requirements will be set during MDP scoping.

- *Modeling alternatives:* If applying the HSPF model with regional parameters, the King County Runoff Time series or Santa Barbara Urban Hydrograph method models, stream flow monitoring should be done to provide rough verification of these models to the natural response of the site under existing conditions. This results in more accurate design flow estimation and better assessment of pre-existing to post-development conditions.

- *Period of record:* For site-specific HSPF calibration, a minimum of 7 months of hydrological and meteorological data is needed. Six of these months should be in winter (October - May). For stream low flow or dewatering problems, the monitoring period should bracket the low flow period (July - October) as well as 3 months during wet weather. For noncalibrated models, monthly readings for the same time period are needed. If both low flow and winter high flow periods are of concern, 12 months of continuous monitoring will be required.

3. Limited Scope MDP

a. Hydrologic modeling

Baseline stream flow monitoring can be limited if: (1) a subbasin comprises less than 35 percent of the upstream catchment of the resource of concern; (2) the percent forest in the site subbasin exceeds 85 percent; or (3) the site is hydrologically simple. (Hydrologically simple sites include those with uniform till soils, few wetlands, and no regionally significant resources sensitive to hydrologic changes in the site catchments.) In these cases, models other than calibrated HSPF can provide satisfactory results.

C. FISHERIES

1. Stream Monitoring: All MDPs

The fisheries monitoring requirements are based on stream survey practices currently adopted by the Department of Development and Environmental Services (DDES). There is no limited monitoring scope for fisheries resources.

- Purpose for assessment:
  - To assess existing stream conditions for:
    - potential fish use,
    - fisheries resource value, and
    - condition of stream.
  - To establish a baseline condition for comparison with post-development monitoring.

- Principal concerns:
  - Sedimentation of spawning gravels
  - Change in channel morphology due to changes in discharge (hydrology)
  - Change in fish population/species composition
  - Change in stream habitat and biotic support potential
  - Change in water quality impact to fisheries

- Parameters for preliminary fisheries assessment:

  The baseline assessment—fish use, habitat, water quality, riparian condition—are used to establish the monitoring program. Habitat elements refer to aspects such as pool-riffle ratio, in-stream cover, amount and condition of spawning gravel, large organic debris, allochthinous inputs, and retention and riparian cover. A step-wise process is to be used to determine the level of assessment to be carried out. A preliminary fisheries assessment shall be conducted for all streams on-site. From the preliminary fisheries assessment, a determination shall be made as to whether the adopted Stream Survey Report Criteria shall be initiated (Level I, II, or III stream survey).

  Use historic documents to identify the following:
  - Fish usage - All streams on-site
  - Flow regime (perennial or intermittent) - All streams on-site

- Parameters to monitor: Please refer to King County Stream Survey Report Criteria BALD, 1991) for details. (Attachment 4)

2. Selection Criteria for Assessing Resources for Fisheries

All streams on-site that meet the King County Sensitive Areas Ordinance definition, i.e., where surface water produces a defined channel or bed. The channel or bed need not contain water year-round.

D. WATER QUALITY

1. Background for Changes in the Water Quality Section

The approach to water quality monitoring has been changed in these guidelines from the approach used in the past. These guidelines seek to incorporate the following aspects:

- To distinguish between monitoring needed to evaluate resources and prepare the MDP and those needed to establish a baseline from which post-development changes would be measured.

- To reduce monitoring in cases where impacts would be very difficult to detect, or to delay monitoring when the location of potential sources was of primary importance in locating sampling stations, such as for groundwater concerns.

- To add monitoring for sensitive wetlands.

- To add a biological monitoring component to streams and fens/bogs.

- To stratify samples to particular seasons as much as possible to reduce data set variability, thus increasing the likelihood that statistical tests of pre- and post-development differences might be successfully employed.

- To increase replication and hence reliability for the data that are collected.

- To maintain a measure of the phosphorus loading into downstream lakes.

The pre- and post-development guidelines for water quality as contained in this document are a first attempt to meet these objectives. SWM is currently refining the set of water quality monitoring parameters and frequency proposed to allow greater statistical rigor to be employed, while remaining cost-neutral to the draft proposal given here. The EPA optimization program developed by MacDonald, et al., 1992, is being employed, as well as consultation with experts in experimental design.

2. Standard MDP

a. <u>Lakes</u>

- Purposes for monitoring:
  - To assess the trophic status of the lake.
  - To establish a baseline condition against which to measure post-development changes using a before/after experimental design.
  - To determine if nutrient loading from project development is within the range predicted in the MDP (see Streams).

- Principal concerns:
  - Increase in nutrients causing excessive algal growth
  - Alteration of light penetration (if lake colored) leading to increased algal growth
  - Depletion of DO—aquatic life protection, nutrient release
  - Changes in lake stratification—effects on DO
  - Increase in nuisance weeds—beneficial use impairment
  - Increase in sediment contaminants—aquatic life protection

- Parameters to monitor: Frequency (per station):

Parameters to monitor:		Frequency (per station):
· Nutrients:	TP, TN, chlorophyll a	Monthly, DJF, JJA
· Physical:	secchi depth	Monthly, DJF, JJA
	temperature profile	Monthly, JJA
· DO profile	Monthly, JJA	
· Sediment metals: zinc, copper		Once, three replicates

- Algal species characterization* June or chlorophyll a peak
- Air photo analysis for macrophytes (Scale should be 1:63,000 or less.) Summer flight

Number of stations: Two mid-lake stations. Depth profile (1 meter intervals) for temperature, DO. Nutrients should be a depth composite. Air photos for aquatic macrophyte analysis assume photometry is available through other sources in detail sufficient to interpret macrophyte beds. Summer photometry is preferred, but other seasons could be used if no summer photos are available. The sediment station should be located at a lake inflow receiving stormwater from the site.

b. Fen/bog wetlands

- Purposes for monitoring:
  - To establish a baseline condition against which to measure post-development changes using a before/after experimental design.
  - To determine the sensitivity of the wetland to development.
- Principal concerns:
  - Increase in nutrients—plant community changes
  - Increase in alkalinity, pH—disintegration of sphagnum mat
  - Increase in bacteria—disrupt equilibrium between growth and decay of organic matter
  - Increase in water level fluctuation—effect on mat and plant community
  - Increased trampling from people and pets—effect on mat and plant community

- Parameters to monitor: Frequency (per station):

Nutrients: TP, TN, ammonia, $NO_2 + NO_3$	Once, wet season
pH	Once " "
Major cations (alkalinity), anions	Once " "
Staff and crest gage	Monthly, October - May
Fungal and bacterial assessment*	Once, wet season
Vegetation transect*	Once " "

**** Only plankton species need be characterized.***

Number of stations: Water samples—three stations from pools within the sphagnum mat. Two vegetation transects at a minimum should be done. One station for staff and crest gage readings is sufficient; placement should be within the permanently inundated pool.

c. Streams

- Purposes for monitoring:
  - To assess the biotic resource value of the stream.
  - To determine the nutrient loading to downstream lakes.

- To establish a baseline condition from which to measure post-development conditions using a before/after experimental design.

- Principal concerns:
  - Increase in sediment—habitat and benthic community alteration
  - Increase in nutrient loading to downstream lakes, ombrotrophic wetlands
  - Increase in temperature, depletion of DO—aquatic life protection

Parameters to monitor:	Frequency (per station):
Nutrients: TP	Monthly, October - May, storms
DO	Twice in summer (JAS)
Physical: temperature, pH, conductivity	Three times: summer, winter, spring
Biotic community assessment	Twice: winter, spring (JFMAM)
Flow (if hydrologically connected to Class 1 wetland)	Seven months (October - May), storms or continuous record Record minimum summer flow.

Number of stations: Generally two stations per stream should be sampled for water chemistry parameters, the upstream station being located above any potential changes induced by the project. Storm samples should be composites and should take into account the lag time in delivery of water from the surrounding catchment. Flow-weighted composites are preferred, but time-separated composites may be acceptable if flow variation during storms is not great.

The biotic community assessment should be replicated in similar microhabitats at three to five stations per stream reach. The data should be discrete rather than composited (Washington State Department of Ecology, 1992). Flow conditions should be recorded and matched for post-development monitoring. Flow data need be obtained from only one station.

**** Method for vegetation transects and fungal assessment to be developed.***

d. Groundwater

- Purposes for monitoring:
  - To determine the potential for post-development transport of pollutants to surface water resources via shallow groundwater and interflow.
  - To determine possible changes in the direction and depth distribution of the shallow groundwater flow after development.
  - To determine the contribution of groundwater to phosphorus sensitive lakes and wetlands.

- Principal concerns:
  - Potential pollutant transport to surface water features and domestic use wells or springs located nearby, particularly if septic tanks are the intended method of wastewater disposal, or if industrial or nutrient generating land uses are proposed

- Groundwater contribution of nutrients to sensitive lakes and wetlands, potentially negating the effectiveness of BMPs
- Changes in interflow causing drying of small, shallow wetlands or small streams on and near the site

Parameters to monitor:	Frequency (per station):
Nutrients: TP, SRP, TSS (as check), NO_2, NO_3	Three times, winter
pH Three times, winter	
Fecal coliforms, pesticides, other pollutants depending on land use	Three times, winter
Piezometers with crest indication (depth to groundwater)	Monthly, one year

Number of stations: Groundwater samples—one station for each receptor of concern. Portions of baseline monitoring may be delayed until after preliminary plat approval, if parameters are dependent on the land uses which are still undetermined at the preliminary application phase. Piezometer locations on-site should be down the hypothesized ground-water gradient and in sufficient number (three at minimum) to determine the predominant direction of groundwater movement, as well as to identify recharge and discharge areas. Soil pits may be necessary in some cases.

3. Limited Scope MDP

a. Lakes

- Parameters and frequency same as standard scope

Number of stations: Same as standard scope

b. Fen/bog wetlands

- Parameters to monitor: Same as standard MDP

Number of stations: Same as standard MDP

c. Streams

Parameters to monitor:	Frequency:
Nutrients: TP	Five winter storms (NDJ)
Physical: temperature	Two times, summer (JJAS)
Flow	Two winter months (in sequence)

Number of stations: Two stations per stream for water chemistry parameters. Storm samples should be composites and should take into account the lag time in delivery of water from the surrounding catchment. Flow-weighted composites are preferred, but time-separated composites may be acceptable if flow variation during storms is not great. Flow data need be obtained from only one station.

d. Groundwater

- Parameters and frequency same as standard MDP

4. Selection Criteria for Monitoring Water Quality of Resources

The above sections address the purpose, extent, and frequency of water quality sampling to support MDP preparation. Determination of which resources to monitor on a particular site is, of necessity, somewhat subjective. Attributes of the resource itself, such as importance, regional or local significance and sensitivity or resilience, as well as the overall cost of monitoring, are typically considered. The guidelines also discuss when it is acceptable to use data collected by others to characterize resources.

a. Lakes

Monitoring data should be collected for all lakes on or adjacent to project sites, unless it can be substantiated that the lake is not phosphorus sensitive within a range of potential loading increases likely to be contributed by urban development (based on published literature of phosphorus loadings). Off-site lakes should also be monitored if the development proposal comprises over 15 percent of the lake catchment area, or if the lake is a resource of regional significance and is phosphorus sensitive.

Data collected through other monitoring efforts may be utilized in lieu of the monitoring suggested in these guidelines, provided that the watershed of the lake has not changed substantially since the time of data collection. As a rule of thumb, if no more than 20 percent of the lake watershed has been disturbed or developed subsequent to data collection, the previously collected data could be regarded as currently representative. Monitoring data from other sources should include data validation information specific to the data set.

b. Fen/bog wetlands

All fens and bogs on or adjacent to the project site should be monitored, if alteration of the fen catchment is proposed. If the fen or bog is associated with an off-site lake or wetland, sampling of the fen portion of the lake or wetland should occur if drainage from the site will reach the fen portion of the lake.

c. Streams

Generally, Class 1 and 2 streams on or adjacent to the project site should be sampled for water quality, as suggested in these guidelines. If there are more than three Class 1 or 2 streams on-site, and if geologic and geomorphological characteristics of the subbasins are similar, representative streams can be chosen to limit the number monitored. Class 3 streams or ephemeral streams need not be sampled for biota or summer water chemistry parameters.

Off-site streams of regional significance and Class 1 streams should be sampled if they are within one-half mile of the site (unless drainage from the developed site would not reach the stream).

The relationship between flow generated from the site and average annual stream flow will be considered in determining whether monitoring is needed.

d. Groundwater

Groundwater level data should be collected if septic tanks are the proposed method of wastewater disposal, or if an industrial use, golf course, or agricultural land use is proposed with the development. Nutrients should also be measured in the groundwater if a lake or fen/bog wetland occurs on or adjacent to the site. Appropriate pollutants and nutrients should be measured if there is a land use or pollutant source upgradient of a lake or ombrotrophic wetland, or if a stream discharging to such water bodies is on or adjacent to the site.

IV. POST-DEVELOPMENT MONITORING

A. INTRODUCTION

Post-development monitoring occurs over three distinct time periods, beginning with the construction phase and extending through improvements and ending with a period of monitoring after full buildout. These guidelines also differentiate between monitoring for four distinct purposes: construction, implementation, facility performance, and resource monitoring (please see table in the introduction of these guidelines). Construction monitoring includes the construction of the plat improvements, such as roads and sewers, as well as the housing structures themselves. Implementation monitoring seeks to answer the question, "Did we do what we said we'd do?" It establishes that the mitigation measures and designs that were given in the MDP were carried out as planned and stops short of asking how well they are working. The last two types of monitoring take up that question.

Facility performance monitoring seeks to determine if the facility was installed according to design, and whether the expected functions of the facility are indeed being delivered; whether the release rate is in the range expected, or whether the pollutant removal is as expected. Resource monitoring attempts to determine whether the impacts to selected resources are within the limits expected by the combination of site design, best management practices (BMPs), and an educated citizenry.

B. CONSTRUCTION MONITORING

Construction monitoring is routinely carried out by the Department of Development and Environmental Services (DDES) and will not be discussed here in detail. The King County Surface Water Management (SWM) Division is available to provide technical assistance should questions arise during construction, and may be involved in the review of construction monitoring reports, depending on the specific project.

Construction is a critical period of time for post-development monitoring. The impacts of construction on resources are not necessarily temporary, even though the construction phase itself is temporary. For instance, if nutrient loading to lakes is a concern, sediment that might escape sites during construction has the potential to alter the lake nutrient budget just as much as changes which occur during the occupancy phase. It would be misleading to use data gathered before the construction period to compare post-development effects if the lake nutrient budget was significantly affected by construction phase sediments. Therefore, care and attention to good construction phase controls and monitoring are critically important.

SWM will work closely with DDES and through the State Environmental Policy Act (SEPA) process to assure that construction-phase impacts are mitigated to the extent possible, and that if there are problems, they are adequately documented and corrected

C. IMPLEMENTATION MONITORING

Implementation monitoring is a cost-effective and straightforward step in the overall monitoring process. Implementation monitoring simply seeks to establish that the mitigation measures and designs that were given in the MDP are carried out as planned. It seeks not so much to determine whether the mitigations are working, but whether they are actually provided. Sampling is typically not required, and timely feedback can be provided to redress any problems noted.

Since mitigations identified in MDPs can range in time from the early construction of improvements such as roads to later construction of residences, and finally to the occupancy phase, implementation monitoring by necessity spans multiple years. Currently, DDES provides implementation monitoring via the engineering plan review and inspection process.

SWM will continue to work closely with DDES to determine how implementation monitoring can be most efficiently carried out.

D. FACILITY PERFORMANCE MONITORING

Monitoring in this category is aimed at stormwater management facilities only. Retention/detention ponds (R/D), infiltration facilities, and water quality facilities (if separate from R/D ponds) are the primary facilities of interest.

1. R/D and Infiltration Facilities

- Purposes:
  - To assure facilities perform as expected to store and release stormwater.
  - To allow for minor facility modifications to achieve expected performance.

- Principal concerns:
  - Facility failure
  - Performance uncertainty due to model
  - Overtopping
  - System maintenance

- Hypothesis: R/D facilities store and release stormwater within the levels and flows expected within a 20% margin of error.

- Parameters to monitor:

Parameters to monitor:	Frequency:
R/D facility	
staff and crest gage	Monthly
Infiltration facility	
infiltration test	Twice
staff and crest gage	Monthly

Number of stations: One staff and crest gage to be installed in each runoff control facility. Two infiltration test locations are needed in each infiltration pond.

Duration of monitoring: A minimum of four years is suggested for monitoring. Monitoring should be timed so that three years of data are collected after the 75 percent buildout threshold is attained. Infiltration testing shall be done at the start and the end of the monitoring period.

Format of information requested: Both an annual status report and a final report analyzing facility function, any problems encountered, solutions attempted and their effect, and any further proposed mitigations.

2. Water Quality

- Purposes:
  - To assure facilities perform as expected to remove pollutants of concern.
  - To allow for minor facility modifications to achieve expected performance.

- Principal concerns:
  - Facilities are performing according to expectations for TSS and TP removal.
  - Performance for other pollutants of concern are within the expected range.
  - Verify sediment accumulation rates for maintenance scheduling.

- Hypothesis to test: Observed pollutant removal equals the target pollutant removal (error margin = 20%).

- Parameters to monitor: Frequency (per station per year):

Parameters to monitor	Frequency (per station per year)
TSS	Three storms
Turbidity	Three storms
Metals: zinc (hardness)	Three storms
pH Three storms	
Nutrients: TP, SRP	Three storms
Depth of sediment in forebay	After one year, three locations, one month duration

Number of stations: Storm samples should be a flow-weighted composite for both the pond inflow and outflow, adjusting timing of the outflow sample for flow-through of the current storm's water. Either automatic or manually composited samples are acceptable.

Duration of sampling: Sampling should commence one year following full site buildout. Three storm events during one wet season are sufficient unless performance problems are observed. In the case performance is substandard, modifications to the facility or to maintenance procedures should be made. Follow-up sampling should then be done to determine if performance has been improved.

E. RESOURCE MONITORING (REPRESENTATIVE RESOURCES)

Note: These resource monitoring guidelines can be applied equally well to site resources or to "representative" resources. If representative resources are chosen for monitoring, sampling sites should be increased, if possible, to increase the ability to use statistical analysis tools.

1. Geotechnical

- Purpose:
  - To assure stream channel stability is within expected parameters.
  - To assure groundwater data is available to support needs of other disciplines (see Wetlands).

- Hypotheses to test: Disruption of normal stream channel processes is not occurring in the post-development period.

- Parameters to monitor:
  - Stream channel changes
  - Groundwater levels

Stream study reaches with transects (frequency): A minimum of three observation periods are needed to monitor impacts at the baseline reaches. The reaches should be assessed at years 1, 3, and 5, after construction startup and at full buildout for the limited scope MDP (see page A-21). For the Standard MDP, the reach should also be assessed at year 10.

Piezometers: Generally, water level observations should be made monthly, seasonally, or biannually, depending on the site and project requirements. Piezometer locations may be coordinated with wetland monitoring used to monitor wetlands for groundwater levels (see Hydrology) and monitoring wells used for groundwater chemistry monitoring (see Water Quality).

Monitoring wells: If locations are appropriate, wells used for groundwater chemistry monitoring (see Water Quality) could also be used for monitoring groundwater fluctuation.
Duration of monitoring (groundwater): To be determined during scoping.

2. Hydrology

- Purpose:
  - To confirm that the level of resource protection specified in the MDP is provided.

a. Wetlands

Monitoring of hydroperiod in Class 1 wetlands may be appropriate, depending on the site.

- Hypothesis to test: Change in average annual water level fluctuation does not exceed acceptable limits after the site is fully developed. Summer drying is not extended more than 2 weeks beyond average pre-developed dry period.

- Parameters to monitor: Frequency:

Parameters to monitor	Frequency
· Staff and crest stage gage readings	Monthly (FMAM, JAS)
· Duration of summer drying	(JASO)

Duration of monitoring: Two consecutive years should be monitored.

Commencement of monitoring: Changes in the wetland hydroperiod would not be expected to occur until after buildout. It is suggested that monitoring not commence until one year following full buildout.

b. Streams

- Hypothesis to test: Flow regime alterations are not causing loss of drainage system performance. Low flows are not reduced beyond limits disclosed in the EIS.

- Parameters to monitor: Frequency:

Parameters to monitor	Frequency
· Stage/crest gage	If HSPF used: continuous record If event model: monthly readings of crest water levels
· Precipitation	Continuous or monthly
· Groundwater levels across representative stream cross section (upland to riparian)	

Number of stations: One station above and below R/D pond outlet. Specific stream selection is dependent on factors such as identification of critical resources and storm drainage facility release locations and potential impacts.

Duration of monitoring: One year of continuous record after completion of site utility improvements and an additional three years after buildout. (Buildout is defined as occurring when at least 75 percent of the permitted structures are built and occupied.)

Format of information requested: Yearly status reports should provide a record of stage and discharge, rating curves, and site observations. Any record discrepancies or deletions should be reported. King County may use the record for a post-development model verification. A final report at the culmination of the monitoring is requested.

3. Fisheries

Depending on the site and resource, it may be appropriate to do an annual stream survey of representative reaches of stream, noting any reduction in habitat quality, diversity, or fish population. If a Level III stream baseline survey was done, a Level III stream survey for post-development may be appropriate. Fisheries assessment would also draw on reports prepared for geotechnical (stream transects), hydrological (flow gaging), and water quality (biotic community assessment) components of post-development monitoring.

- Hypotheses to test:
  - Flow regime alterations are not causing a significant degradation of spawning and rearing habitat.
  - Fish migration is not impeded by post-development changes in stream channels.
  - Benthic community composition has not changed so markedly as to affect fish populations.

4. Water Quality

a. Lakes

- Purposes:
  - To assure that phosphorus loading to lakes is not greater than anticipated in the MDP analysis.
  - To provide corrective BMPs, including source control and education, if higher than expected phosphorus loadings are experienced.

- Principal concerns:
  - Annual average phosphorus loading
    effects on beneficial uses of the lake
    increase in nuisance weeds
    alteration of light penetration, clarity
    depletion of DO—aquatic life protection
  - Increase in sediment contaminants—aquatic life protection

- Hypotheses to test:
  - The trophic status of the lake after development does not differ significantly from its pre-development trophic status.
  - The concentration of zinc and copper in lake sediments in the post-development phase is equal to the concentration in the pre-development phase (level of significance = 0.75).

- Parameters to monitor: Frequency (per station):

· Nutrients:	TP, TN, chlorophyll a	Monthly, DJF, JJA
· Physical:	secchi depth	Monthly, DJF, JJA
	temperature profile	Monthly, JJA

- DO profile Monthly, JJA
- Sediment metals: zinc, copper — Once, three replicates
- Air photo analysis for macrophytes — Summer flight

Number of stations: Two mid-lake stations. Depth profile (every meter) for temperature, DO. Chlorophyll a should be a photic zone composite, and nutrients a depth composite. Air photos for aquatic weed analysis assume photometry is available through other sources in sufficient detail to delineate macrophyte beds. Summer photometry is preferred, but other seasons could be used if no summer photos are available. A sediment sample should be taken at an inflow (stream or storm drain) transporting stormwater flows from the site.

Duration of monitoring: Monitoring should commence one year after 75 percent site buildout, and for three consecutive years thereafter.

b. <u>Fen/bog wetlands</u>

- Principal concerns:
  - Increase in nutrients—plant community changes
  - Increase in alkalinity, pH—disintegration of sphagnum mat
  - Increase in bacteria—disrupt equilibrium between growth and decay of organic matter
  - Increase in water level fluctuation—effect on mat and plant community
  - Increase in trampling—effect on mat and plant community

- Hypotheses to test:
  - The alkalinity of the bog after development does not differ from the pre-development alkalinity (level of significance = 0.75).
  - The range of monthly wet weather water levels does not change significantly after development (level of significance = 0.75).
  - The vegetation community composition of the bog mat does not differ markedly from the pre-development community (may not be statistically testable from limited data set).

- Parameters to monitor: — Frequency (per station):
  - nutrients: TP,TN, ammonia, $NO_2 + NO_3$ Once, wet season
  - pH Once " "
  - Major cations (alkalinity), anions — Once " "
  - Staff and crest gage — Monthly, October - May
  - Fungal and bacterial assessment* — Once, wet season
  - Vegetation transect* — Once " "

Number of stations: Water samples—three stations from pools within the sphagnum mat. Two vegetation transects should be done, at a minimum. One station for staff and crest gage readings is sufficient; placement should be within the permanently inundated pool.

Duration of monitoring: Since it is anticipated that there would be a lag time between full buildout and the time potential effects would be measurable, and that effects would become more pronounced over time, it is recommended that monitoring for fen/bog resources take place for three years after full build-out, at years 3, 5, and 7.

c. Streams

- Principal concerns:
  - Increase in temperature, depletion of DO—aquatic life protection
  - Increase in nutrient loading to downstream lakes, ombrotrophic wetlands
  - Increase in sediment—habitat and benthic community alteration

- Hypotheses to test:
  - Summer and early fall temperature and DO conditions are not limiting to aquatic life.
  - The post-development wet weather phosphorus loading to downstream lakes is not greater than that predicted in the MDP (level of significance = 0.75).
  - The post-development benthic stream community composition has not shifted markedly.

Parameters to monitor:	Frequency (per station):
Nutrients: TP	Monthly, October - May, storms
DO	Twice in summer (JAS)
Physical: temperature, pH, conductivity	Three times: summer, winter, spring
Biotic community assessment	Twice: winter - spring (JFMAM)
Flow	Six months (ONDJFM), storms or continuous record

**** Method for vegetation transects and fungal and bacterial assessment is to be developed.***

Number of stations: Generally two stations per stream should be sampled for water chemistry parameters, the upstream station being located above any potential changes induced by the project. Storms samples should be composites and should take into account the lag time in delivery of water from the surrounding catchment. Flow-weighted composites are preferred, but time-separated composites may be acceptable if flow variation during storms is not great.

The biotic community assessment should be replicated in similar microhabitats at three to five stations, with the data being discrete rather than composited or pooled (Washington State Department of Ecology, 1992). Flow data need be obtained from only one station.

Duration of monitoring: Sampling should take place for three years and begin after project buildout.

Analysis suggested: Compare post-development data with baseline data and water quality standards. For phosphorus loading, use appropriate statistical tests to test for significant differences. For biotic information, identical collection techniques should be used for baseline and post-development, and the difference in community composition analyzed by an ecologist with expertise in benthic invertebrate communities. If differences are found, determine whether the likely cause is habitat change or toxicity. Recommend mitigating measures if appropriate.

d. Groundwater

- Principal concerns:
  - Potential pollutant transport to surface water features
  - Groundwater contribution of nutrients to sensitive lakes and wetlands, potentially negating the effectiveness of management BMPs
  - Changes in interflow causing drying of small, shallow wetlands or streams on and near the site

- Hypotheses to test:
  - Groundwater near sensitive receiving sources is not significantly different in pollutant/nutrient content than in the pre-developed condition.

Parameters to monitor:	Frequency (per station):
· Nutrients: TP, SRP, TSS (as check), TN, NH_3, $NO_2 + NO_3$	Three times, winter
· pH	Three times, winter
· Fecal coliforms, pesticides, other pollutants depending on land use	Three times, winter
· Piezometers with crest indication	Monthly, October - June

Number of stations: Groundwater samples—one station for each receptor of concern. Portions of baseline monitoring may be delayed until after preliminary plat approval if parameters are dependent on the land uses which are still undetermined at the preliminary application phase. Piezometer locations on-site should be across the hypothesized ground-water gradient and in sufficient number to determine the predominant direction of groundwater movement, as well as identify recharge and discharge areas.

Duration of monitoring: One time, two years after full buildout

V. ATTACHMENTS

ATTACHMENT 1

HYDROLOGIC MODELING REPORT CONTENT: HYDROLOGIC SIMULATION PROGRAM-FORTRAN

1. Data Collection

The consultant will provide:

- Precipitation data collected at a 15-minute frequency within the basin

- Stream flow data collected at a 15-minute frequency

- Wetland stage data

- Channel cross sections, slopes, and roughness used to compute flow tables for routing

- Wetland bathymetry and calculation of storage discharge relations used to compute flow tables for routing

- Long-term precipitation and evaporation records for computing flow frequencies

- All precipitation, stream flow, wetland stage, and evaporation data will be stored on MS-DOS computer disks in ASCII file format.

2. Model Calibration

The consultant will provide:

- Maps of calibration land use, geology, soils, subcatchment boundaries, and locations of calibration gages. Geology and soils maps must be based on field investigations and documented in either this report or the "Geotechnical Investigations" report.

- HSPF computer input files that contain:

  a) Calibrated HSPF PERLND parameters
  b) Flow tables representing channel hydraulics
  c) Network multiplication factors for calibration land use

- A hard copy modeling inputs and outputs that clearly document the calibration

- A report summarizing the calibration. This report will contain, at a minimum, the following components:

  a) Graphs of simulated versus recorded peak and average daily flow or stage at each gage

b) Graphs of individual hydrographs or stage for the three largest storms in the calibration record for each gaging station
c) Statistics comparing simulated versus gaged peak and mean daily flow or stage at each gaging station

3. Hydrologic Analysis of Existing Conditions

The consultant will provide:

- The calibrated HSPF model will be run at a 15-minute time step using transposed rainfall data from the SeaTac weather station.

- The following information will be provided at the outlet of each modeled subcatchment:

  a) Flow frequencies
  b) Flow and/or stage durations
  c) At each lake or wetland, durations of stage and area of inundation will be provided.

4. Hydrologic Analysis of Developed Conditions

The consultant will provide:

- Maps of developed land use, geology, and subcatchment boundaries

- HSPF computer input files that contain:

  a) Calibrated HSPF PERLND parameters
  b) Flow tables representing channel hydraulics
  c) Network multiplication factors for calibration land use

- Designs of proposed detention ponds or lakes based on matching flow and/or stage durations

- Existing versus developed flow and/or stage durations at the outlet of each modeled subcatchment

- For each wetland or lake, durations of stage and area of inundation under existing and developed conditions

ATTACHMENT 2

STANDARDIZED FIELD INSTRUMENTATION AND GAGING CRITERIA

Following are specifications for installations used to monitor water levels and stream discharge in conjunction with Master Drainage Plans. These specifications allow the King County Surface Water Management (SWM) Division staff to periodically verify and, at times, augment data collection efforts of the applicant.

1. General

All installations must be built so as to resist tampering and impact from natural causes. Gages must be tied in to local benchmarks so that water surface elevation may be related to local topography. Where necessary, it is the applicant's responsibility to secure a Washington State Hydraulic Project Approval.

Copies of all raw stage records and related field notes, including stage and crest stage gage readings, will be provided to SWM Division monitoring personnel on, or about, May 1 and November 1 of each year.

2. Staff Gages

Staff gages, used to monitor water levels, shall have demarcations in hundredths of a foot and be readable (without aid) from the bank of the body being monitored.

Staff gages are to be read no less than once per month.

3. Crest Stage Gages

Crest stage gages, used to record peak water levels between visits, shall be constructed as shown in Figure 1, and installed according to the staff gages described above.

Crest stage gages are to be read no less than once per month, and after each major storm.

4. Stage Recorders

Stage recorders shall record the water level every 15 minutes and be of a type that can be downloaded via an IBM compatible laptop computer. A logger with a nonresetting circular memory is preferred, as it eliminates the need to coordinate upload sessions between King County and the applicant. Output must be in an ASCII file in which a date stamp, and no more than one 15-minute value, appear on each line.

5. Precipitation Recorders

Precipitation recorders, monitoring a tipping bucket rain gage, calibrated to 0.01 inches per tip, shall log total rainfall every 15 minutes and be of a type that can be uploaded via an IBM compatible laptop computer. A logger with a nonresetting circular memory is preferred, as it eliminates the need to coordinate upload sessions between the County and the applicant. Output must be in an ASCII file in which a date stamp, and no more than one 15-minute value, appear on each line. It is advisable to have both precipitation gages and stage recorders operate off the same type of data logging system.

If the data logger selected is not in use by the SWM Division monitoring program, the applicant must provide software, cables, and operating instructions to monitoring staff.

Any sensor may be used so long as the resolution is no less than 0.02 feet and the drift does not exceed 0.04 feet/month. All stage recording installations shall include both a staff gage and crest stage gage, as described above.

It is strongly recommended that stage recorders be uploaded and serviced no less than 12 times per year.

6. Control Structures

All water level monitoring stations located on discharge channels or in wetlands with surface outflows must have rated control structures or sections. Acceptable control structures include an appropriately sized weir or flume, a culvert in good condition, or a stable section of stream channel. Stage-discharge ratings for all controls, and/or flow measurement data collected to create or confirm channel ratings, must be provided to the monitoring program along with related stage data.

ATTACHMENT 3

WATER QUALITY SAMPLING AND QUALITY ASSURANCE CONSIDERATIONS

In any study in which samples are taken to represent a larger population, the extent to which the samples accurately represent the population is an issue. It is always possible to draw a sample that is a fluke—that doesn't represent the population well. The best way to ensure representativeness is to take a number of samples. If the sample size is large, it is more likely that the sample accurately reflects the population from which it is drawn. In general, sample sizes of between 20 to 30 are usually considered large.

In sampling rainfall runoff, other concerns are also relevant. The pollutants that are carried in the runoff can vary, both during the storm, and between different storms. For instance, pollutants can be more concentrated in the early part of the storm, or perhaps are only present if very heavy rainfall mobilizes them. There can be contamination by outside sources, such as from the containers used to convey the sample. Additionally, there are also considerations about the accuracy to which the analytical laboratory can quantify the concentration of a particular pollutant.

All these concerns, which include the extent to which the sample accurately represents the storm runoff, the inherent variability in pollutant concentrations, possible contamination from outside sources, and the accuracy of the laboratory quantitation, are factors to consider in designing the quality assurance aspects of a project.

1. Representativeness of Sample

Flow-proportioned samples are preferred for Master Drainage Plan (MDP) monitoring rather than grab samples or samples at evenly spaced time intervals, because they are considered more representative of the actual stormwater runoff. Since a rainstorm extends over time, and a grab sample taken at only one point in time, it is not likely to represent the "true" pollutant concentration. Several samples evenly spaced over time would seem to better represent the average pollutant load. Further, if flows are relatively constant, a time-proportioned sample, as it is called, may indeed be a good estimate of the "true" pollutant load carried.

But rainfall runoff is not constant. A typical hydrograph has one or more peaks, with periods of increasing and decreasing flows. Assuming the contribution of pollutants is fairly constant, samples taken at regular time intervals would ignore the effect of the greater or lesser flow volume in diluting or concentrating pollutants. It would also be difficult to compare results from different rainfall events.

The problem of unequal flow can be dealt with simply by monitoring the flow. Knowing the flow at any time allows an automatic sampler to be programmed to collect a sample after a given increment of flow has passed. The harder it rains, the more samples that are collected. The problems with dilution of pollutant concentrations during high flow and concentration during low flows are avoided. If manual sampling is done, knowledge of the flow also allows the same process to be done by the sampling technician. Thus, flow-proportioned stormwater samples, though not perfect, are more likely to be representative than time-proportioned samples.

In addition to concerns about whether the storm runoff is sampled in a representative manner, another concern is about the selection of the storms themselves. One way to ensure representativeness in selecting samples is to employ random sampling. Random sampling means that the particular sample taken is as likely to be drawn as any other. Biases that may be affecting the population are therefore minimized. Random sampling results in independent observations, an outcome important for applying statistical analysis.

Random sampling may also be stratified; that is, only a certain subset of the population may be sampled.

However, strict random sampling is difficult to apply to storm monitoring. Rainfall events themselves could be viewed as randomly occurring. There is usually poor information about the likelihood, duration, and intensity of rainfall events before they occur. Due to the difficulty of identifying and then randomly selecting a stratified sample, MDP project monitoring is not expected to collect storms randomly.

2. Variability in Target Pollutant Concentration

It was mentioned above that one assumption of flow-proportional sampling is that the pollutant concentration is constant. In reality, it is difficult to know how the pollutant loading is distributed over the storm without intensive, incremental monitoring. Even then, it is unlikely that the distribution would be the same for each storm. As an example, the table below compares data for two storm inflow samples from a storm sampled on January 10, 1992. One sample is for the entire event; the other is for the last hour only. For most constituents, the last hour showed lower pollutant concentrations than for the entire storm event. An exception was the nitrate-nitrite concentration, which was higher during the last hour. Dissolved metal concentrations were near the detection level in both samples. This event produced 0.25 inches of rain in 4.5 hours, with an average flow of 0.04 cubic feet per second.

Table 1: Comparison of different sampling periods, January 10, 1992 storm inflow samples

PARAMETER	FLOW-PROPORTIONED ENTIRE STORM	LAST HOUR	COMMENTS
$NO_2 + NO_3$	0.33 / 0.32	0.64	Higher
Ortho P	< 0.005*	< 0.005	Below DL
TP	0.13 / 0.15	0.024*	Lower
BAP	< 0.018*	< 0.018*	Below DL
TSS	66 / 59	10	Lower
Turbidity	31 / 51	6.8	Lower
Total metals			
Cu	0.012 / 0.008	0.004*	Lower
Pb	0.007 / 0.011	0.017	Higher
Zn	0.042 / 0.065	0.034	Similar
Al	0.58 / 1.7	0.51	Similar
Fe	0.52 / 2.0	0.41	Similar
Dissolved metals			
Cu	0.001*	0.001*	Same
Pb	0.001*	0.001*	Same
Zn	0.024	0.02	Same
Al	0.05*	0.07	Same
Fe	0.02*	0.04*	Same
Fecal coliform	162 / 275	81	Lower

**** Indicates a concentration less than three times the detection level***

Note: Values separated by a "/" for sample 92-A000431 are field duplicates. One method used in this study to estimate the variability in pollutant concentration in stormwater samples was to include field replicas. Instead of filling just one sample container from the composite sample collected, two containers are filled for laboratory analysis.

3. Contamination Concerns

To check for possible contamination being introduced into the sample from the collection equipment, "blanks" are commonly run. Both field rinsate blanks and general field blanks can be collected. A blank is prepared by using a source of water known to be free of contaminants, often deionized distilled water (DDW), and running the typical laboratory analysis on the sample.

For the field rinsate blank, DDW is run through the sampler or collection container after normal field cleaning procedures have been carried out.

Field blanks are also filled with DDW. Containers are filled and labeled in the field, then treated identically to stormwater samples and submitted for laboratory analysis. These blanks serve to check for additional sources of potential contamination, such as from containers, sample transferring, and from the laboratory analysis process itself.

4. Accuracy of Analysis

In addition to concerns about representativeness of the sample, variability in the stormwater itself, and possible extrinsic contamination sources, there is an additional set of concerns about the accuracy of the laboratory analysis. These will only be discussed briefly, since other documents thoroughly discuss this material (Bleyler, R., 1988, Ecology, 1988).

a. <u>Holding times</u>

Specific holding times and preservation techniques have been established for a number of laboratory analysis. The holding times specified in the 30 CFR 136, Federal Register, Volume 49, No. 209, Friday, October 1984 should be used. Compliance with holding times should be determined by comparing the dates for sample digestion or analysis with the sample delivery date (sample delivery was the same day as sample collection, unless samples were either frozen or otherwise preserved, as discussed in the sampling plan).

b. <u>Detection limits</u>

Detection limits for each analysis are typically reported on the laboratory data report. Most of the time, the detection limit reported is the same as the instrument detection limit. In general, reliable quantitation of a chemical is not possible at the detection level (DL). For most chemicals, a factor of 3 to 5 is applied to the detection level to obtain an accurately and reproducibly quantified number, which is referred to as the quantitation limit (Environmental Protection Agency, 1989, page 5-8).

It is suggested that the Data report include data validation worksheets. These worksheets should also indicate whether the value reported is less than 5 times the DL.

c. Matrix spike recovery

This procedure involves adding an analyte to a sample, then running the analysis to see if recovery of the material can be demonstrated. Spike recovery should be within 75 percent to 125 percent.

d. Split samples with other laboratories

Another indication of precision in sample analysis is to analyze the sample in two different laboratories using the same analytical methods.

e. Laboratory duplicate relative percent differences (RPDs)

Laboratory duplicates indicate only the precision of the laboratory method. The sample submitted to the lab is split after delivery to the lab, and both samples run through the analytical method. The RPD between the two samples should be within 20 percent.

f. Other laboratory administered quality control

In addition to the quality control information discussed above, analytical laboratories perform routine quality assurance/quality control in keeping with requirements for laboratory accreditation. Some of these procedures include instrument calibration, use of method and instrument blanks, run duplicates, and interference checks.

Recommended qualifiers used in validating data (after Bleyler, 1988):

- **J** value is an estimate.
- **UJ** value may be below the limit of quantitation.
- **R** value is unusable.

5. Sampling Plan

The following considerations should be taken into account before sampling occurs and a project-specific sampling plan prepared:

- Sampling goals
- Criteria for storm sample collection

To the extent practical, storm events to be monitored should follow a dry period of at least 48 hours from a previous storm that produced significant runoff (approximately 0.1 inches of rainfall). Ideal storms should yield between 0.25 to 0.50 inches of rainfall in an 8 hour period. Very large events (greater than a 2-year, 8-hour storm) should not be sampled.

- Field procedures

- Field log book

A log book should be maintained as a record of all information pertaining to sample collection, handling, and delivery and sampling system maintenance. Types of information to be recorded include:

- Date and time samplers set
- Date and time samples retrieved
- Observations of oil sheen
- Date, time, and stage for oil and grease sample collection
- Splitting and delivery of samples to analytic laboratory
- Any special handling of samples (manual compositing, filtering, preservation, etc.)
- Notes pertaining to troubleshooting and remedial procedures
- Any other notes thought to be of potential use

- Sample handling and preservation

  One acceptable regime for cleaning glassware is as follows:

1) No phosphorus detergent; wash with nylon brush and hot tap water.
2) Hot tap water rinse (four times)
3) Acid rinse with 2 percent reagent grade sulfuric acid
4) Distilled water rinse (six times); one L polyethylene for physical parameters and filtering for orthophosphate and dissolved metals

ATTACHMENT 4

STREAM SURVEY REPORT CRITERIA

July 1, 1991

The purpose of these guidelines is to improve the validity, consistency, and usefulness of fisheries information. The guidelines address the appropriate scope and methods of stream and fisheries studies, and recommend three progressive levels of detail based on stream system classification and fish utilization. This document is subject to change as more information becomes available or new methods are developed. Future efforts should be devoted toward a better understanding and evaluation of the interrelationships among elements of the environment and on improving impact predictions.

A. General Site Survey

1. Natural drainage system configuration and stream classification
2. Riparian zone land uses
3. Riparian vegetation (structure, species composition, and density)
4. Description of adjacent wetlands
5. Animal habitat and utilization
6. Riparian soils, channel morphology, and bank stability
7. Substrate composition
8. Large woody debris and pool quality
9. Benthos (invertebrates)
10. Fish habitat and utilization
11. Photographs taken at 25-foot intervals

B. Stream Survey Data

Level I - Basic:

A habitat and stream channel stability survey is required for all Class 1 and 2 streams that traverse the site. The stream survey must adhere to the methodology developed by the King County Surface Water Management (SWM) Division, as modified from the USDA Forest Service Stream Habitat Classification and Inventory Procedures for Northern California (McCain et al., 1990; attached). The survey shall encompass stream reaches one-quarter mile upstream and downstream of the site, or to the next higher order stream (Strahler, 1957) for Master Drainage Plans and subdivisions. Stream survey requirements for building permits, short subdivisions, and grading and clearing permits shall encompass stream reaches 500 feet upstream and downstream of the site. The habitat survey form, attached, was modified by SWM (Fuerstenberg and Lucchetti, 1990) from methods developed by the USDA Forest Service. Pool quality indexing should conform to criteria developed by Platts (Platts, 1987; attached).

Level II - Intermediate:

In addition to a Level I stream habitat survey, an intermediate survey must be performed to list all fish species known to use the stream. Habitat requirements and season of use must be documented. Use of the "two-pass removal electrofishing method" is recommended for a distance of 300 feet of each stream, or 10 percent of the stream length on the site (whichever is greater). Three sites per stream may be required. Record standard lengths for all salmonids or provide a subsample if certain species are particularly numerous. Presence and relative abundance of nonsalmonids should be recorded.

In streams with spawning habitat: Depending on species presence, survey every two weeks during spawning for chinook, coho, sockeye, steelhead, or other anadromous species. Survey once per month for resident species. Document numbers of redds, live fish, and carcasses.

Spawning or juvenile salmonid survey requirements may be modified or waived if determined unnecessary by SWM and/or BALD.

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Platts, W.S., Armour, G., Boot, G.D., Bryant, M., et al., Methods for Evaluating Riparian Habitats with Applications to Management, USDA Forest Service General Technical Report INT-221, 1987.

Level III - Detailed:

In addition to Level I and II requirements, produce a habitat map of scale 1" = 100_ (1:1, 200) showing:

a) Habitat types (as determined by Level I stream habitat survey)
b) Spawning areas by species (salmonids only)
c) Locations, estimated volumes, and species of large woody debris (any wood at least 10 inches in diameter and 10 feet long) within the channel or associated floodplain/riparian area

Using SWM methodology, establish cross sections for each 300 feet of every Class 1 and 2 stream traversing the site and up to one-quarter mile downstream of the site. If the stream length is less than 300 feet, establish at least three equidistant cross sections. Number and location of transects may be modified by SWM depending on site conditions. For each section, document the following:

a) Bed cross section elevation at 1-foot intervals from the OHWM
b) Substrate composition along the cross section utilizing a leadline methodology (Bain and Finnen, 1985)
c) Representative macroinvertebrate species and numbers along the cross section
d) Stream habitat types within 5 channel widths upstream and downstream of the cross section
e) Position, species, and size of all trees at least 10 inches in average diameter that lie within 10 feet upstream and downstream of the cross section and within a distance of 100 feet of the OHWMs

<u>Minimum Standards of Acceptability</u>:

All studies shall include the following:

a) Map of habitat types and sampling locations
b) Inventory of observed and expected species
c) Detailed description of methodology used and identification of researchers and their qualifications
d) Attachment of copies of field data sheets, labeled with consultant's name, date, location, and activity

<u>References</u>:

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